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RESEARCH PAPER

Effect of Sowing Environment and Varieties on Soil Fertility and Nutrient Uptake of Rainfed Wheat under Sub-tropical Conditions

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ABSTRACT

A field experiment was conducted to assess the effect of sowing dates and varieties on soil fertility and nutrient uptake of wheat crop (*Triticum aestivum* L.) under sub-tropical conditions. The experiment was conducted at the Research Farm, Advanced Centre for Rainfed Agriculture (ACRA), Rakh-Dhiansar of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu-India during the *Rabi* season of 2018-19. The experiment was carried out for six dates of sowing and three varieties with three replications. Initial readings for available nitrogen (165.00 kg/ha) were low, phosphorous (13.75 kg/ha) and potassium (112.00 kg/ha) were found medium in the soil. The soil class was found sandy loam having neutral pH (6.78) and organic carbon with a value of 2.4 g/kg and EC (0.16 dS/m). The soil physico-chemical parameters *viz* pH, EC and OC as well as available N, P and K content of soil after harvest of crops did not show much of variations and thus failed to show any significant difference among varieties and sowing environments. N, P and K uptake in wheat after harvest significantly differed with wheat varieties and sowing environments while the interaction effects of varieties and sowing environments found to be non-significant. However, wheat variety *JAUW-598* removed significantly higher amounts of N, P and K uptake by wheat grain and straw as compared to wheat variety *PBW-175*. As regards the sowing environments, 31st October sown wheat crop removed significantly highest amounts of N, P and K uptake by wheat grain and was followed by 15th November sown wheat crop whereas significantly lowest N, P and K uptake by wheat grain was removed by 14th January sown wheat crop and was followed by 30th December sown wheat crop. Almost a similar trend was observed with respect to nutrient uptake (NPK) by wheat straw as a result of differential times of planting.

HIGHLIGHTS

- Early sowing (31st October) significantly increased nitrogen, phosphorus, and potassium uptake in wheat grain and straw, compared to delayed sowing (14th January). Early sowing ensured better growth, reduced weed competition, and higher nutrient uptake.
- Wheat variety *JAUW-598* recorded significantly higher nutrient uptake (N, P, K) and better yield attributes compared to *PBW-175*.
- Post-harvest soil analysis showed no significant changes in soil pH, electrical conductivity, and organic carbon across varieties and sowing environments.

Keywords: Nutrient uptake, Sowing environment, Soil fertility, Varieties, Wheat

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Wheat, (*Triticum aestivum* L.) belonging to family 'Gramineae' and genus 'Triticum', is one of the world's most widely cultivated food grain crops due to its wider adaptability to different agro-climatic and soil conditions. Globally, wheat (*Triticum* spp.) is grown in about 220 million hectares holding the position of highest acreage among all crops with annual production hovering around 781 million tonnes (USDA, 2019). Major wheat producing countries of the world are China, India, United States of America, France, Russia, Canada, Germany, Turkey, Australia, Ukraine and Pakistan. This nutrient-rich cereal is one of the most important staple food crops of many countries including India. In India, the crop is cultivated in about 29.55 million hectares (13.43 per cent of global area) to produce production output of about 101.20 million tonnes (almost 12.96 per cent of world production) with a record average national productivity of 3424 kg/ha (MoAFW, 2019). It is evident from recent trends that area under wheat cultivation is declining and there is a very little scope for expansion of area in future. Hence, vertical expansion is required for yield enhancement which requires appropriate varieties and agronomical practices while ensuring conservation of natural resource base. Sowing environment plays an important role in productivity of wheat. The appropriate selection of a planting date can have a dramatic impact on both the quantity and quality of crop yield (Gul *et al*. 2008; Singh *et al*. 2021). Late sown wheat in North Indian conditions is exposed to both the extremes of temperature i.e. low temperature during early growth period, which restricts the vegetative phase and high temperature during post anthesis period, which reduces the duration of grain development and consequently the grain yield (Hossain *et al*., 2021; Sagar *et al*. 2022). Drastic reduction in yield of wheat has been recorded with the delay of sowing beyond optimum time (Ram *et al*. 2012). Generally, wheat like other cool season crops is seeded early to take maximum period for growth and development toward maturity before the possible heat stress. Early planting may avoid terminal heat stress by facilitating the grain filling during relatively cooler temperatures (Loss and Siddique 1994). Normally the wheat crop is sown in about 148 thousand hectares of rainfed sub-tropical areas of Jammu region during the first fortnight of November, however if no rains are received during this period and the soils have insufficient soil moisture, the sowing of wheat may be extended to December under late situations and even in January during very late situations. It has been realized that the average yield of wheat of this region, sown during the month of November, is comparable to the state average, but the declining trend in wheat yield has been noticed with delayed sowing which can be attributed to shorter growth period available coupled with higher temperatures and hotter winds during reproductive growth period, which leads to forced maturity and ultimately poor grain yield. At present there is a tremendous scope for increasing the yield of wheat with the use of multi-character high yielding varieties. The huge reduction in yield due to the changing climatic scenario prompts to evaluate optimum time of sowing for different varieties for maximum production towards realizing the desirable productivity levels.

MATERIALS AND METHODS

A field experiment was carried out at Rakh-Dhiansar during the Rabi season of 2018-19. Geographically, the experimental site was located at 32° 39 'N latitude and 74° 53 'E longitude with an altitude of 332 m above mean sea level in the Shivalik foothills of North-Western Himalayas sub-tropical region. The experiment comprised of two wheat varieties (*JAUW-598* and *PBW-175*) under six different dates of sowing (31st October, 15th November, 30th November, 15th December, 30th December and 14th January) and was laid out in Factorial Complete Randomized Design with three replications. All agronomic practices were kept normal and uniform for all the treatments. Surface soil sampling of experimental field from 0-15 cm depth was done from four spots of the field prior to imposition of experimental treatments. Then these samples were air dried, processed and subjected to analysis for their physico-chemical properties. The data recorded in respect of physico-chemical properties of the experimental site revealed that the soil of the experimental site was sandy loam in texture, slightly acidic in reaction, low in organic carbon and available nitrogen but medium in available phosphorus and potassium. After harvesting of wheat crop individual soil samples from all the plots were taken from the surface for determination of pH, EC, OC, available Nitrogen, Phosphorus and

Potassium. The samples were dried under shade, grounded and passed through 2 mm sieve and were analyzed for nutrients. Available nitrogen was determined by modified alkaline permanganate method as described by Subbiah and Asija (1956) and was expressed in kg/ha. Available phosphorus was determined using method described by Olsen *et al.* (1954). The intensity of color developed by stannous chloride (Watanable and Olsen, 1965) was measured at 660 nm on spectrophotometer and was expressed as P kg/ha. Available K was extracted with neutral normal ammonium acetate solution as described by Piper (1966) and potassium was determined by flame photometer and expressed as K kg/ha. The plant samples were taken at the time of harvesting for estimation of N, P and K concentration. The grains of wheat were also taken for uptake studies from each plot. The samples were oven dried, then finely ground with electric grinder and analyzed for nitrogen, phosphorus and potassium concentration. N, P and K uptake in grain and straw samples were calculated by multiplying per cent nutrient content with their respective dry matter accumulation as per the formula given below:

$$\textit{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{Dry matter accumulation (kg/ha)}}{100}$$

RESULTS AND DISCUSSION

The soil physico-chemical parameters depicted in Table 1 *viz.* pH, EC and OC after harvest of crops did not show much of variations and thus failed to show any significant difference among varieties and sowing environments. The values of pH, EC and OC obtained after harvesting of wheat crop ranged from 6.56 to 6.72, 0.17 to 0.18 dSm^{-1} and 2.23 to 2.39 g/kg, respectively under varieties and sowing environments. In general, the pH of the soil decreased and EC increased after harvest of wheat crop. However, the organic carbon of the soils decreased after completion and harvest of wheat crop. This could be attributed to the fact that better crop establishment at early dates of sowing which resulted in better root biomass and higher nutrient uptake.

Available N, P and K

The available soil nutrient status data presented in Table 1 revealed that the available N, P and K content of soil after harvest of wheat crop was not significantly influenced by varieties and sowing environments as well as the interaction effects of varieties and sowing environments. However, among wheat varieties, numerically lower values of available N, P and K were recorded with wheat variety *PBW-175* as compared to wheat variety *JAUW-598*. As regards sowing environments, numerically lowest values of available N, P and K were recorded in 31st October planting and

Table 1: Effect of varieties and sowing environments on soil fertility changes after wheat harvest

Treatment combinations	pH	EC(dS/m)	OC (g/kg)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Factor (A) Varieties						
PBW-175	6.62	0.18	2.29	166.45	12.02	111.13
JAUW-598	6.63	0.18	2.27	167.36	12.21	111.75
SEm±	0.08	0.00	0.04	3.61	0.26	2.22
CD (5%)	NS	NS	NS	NS	NS	NS
Factor (B) Sowing Environment						
31st October	6.72	0.18	2.23	162.82	11.14	109.88
15th November	6.67	0.18	2.24	164.99	11.69	110.03
30th November	6.65	0.17	2.27	166.14	11.74	110.19
15th December	6.62	0.18	2.29	167.18	12.49	112.54
30th December	6.55	0.18	2.32	168.61	12.50	112.93
14th January	6.56	0.17	2.34	171.69	13.14	113.09
SEm±	0.14	0.01	0.06	6.24	0.44	3.85
CD (5%)	NS	NS	NS	NS	NS	NS
Interaction (A*B)	NS	NS	NS	NS	NS	NS

was followed by 15th November sown wheat crop whereas significantly highest values of available N, P and K were recorded in 14th January planting and was followed by 30th December sown wheat crop. The possible reason that could be ascertained to these findings that wheat being exhaustive removed more nutrients from soil. Enhanced nutrient availability under late sown condition could be ascribed to the possible reason that the total uptake by crops in late sown remained lower as compared to other early sown conditions due to competition imposed by weeds and crops as well as short life-cycle.

N, P and K uptake by grain and straw of wheat

The data presented in Table 2 revealed that N, P and K uptake in wheat after harvest significantly differed with wheat varieties and sowing environments while the interaction effects of varieties and sowing environments found to be non-significant. However, wheat variety *JAUW-598* removed significantly higher amounts of N, P and K uptake by wheat grain and straw as compared to wheat variety *PBW-175*. This might have been due to a greater number of tillers and biomass and higher values of yield components produced by wheat variety *JAUW-598* as compared to wheat variety *PBW-175*. Also, *JAUW-598* variety recorded significantly lower total weed density and total weed biomass that might have led to better utilization of resources, hence higher uptakes. Further, it might have been due to better morphological and physiological characteristics of wheat variety *JAUW-598*. Cultivars with a high growth rate generally respond more favorably to fertilizers application than those with the lower growth rates. Such findings were recorded by Pal *et al*. (2017).

As regards the sowing environments, 31st October sown wheat crop removed significantly highest amounts of N, P and K uptake by wheat grain and was followed by 15th November sown wheat crop whereas significantly lowest N, P and K uptake by wheat grain was removed by 14th January sown wheat crop and was followed by 30th December sown wheat crop. The higher uptake of these nutrients in early sown wheat might be attributed to vigorous growth and better root system of wheat which could have helped in adequate supply of these nutrients resulting in higher biological and economic yield coupled with numerically higher nutrient contents of N, P and K. Almost a similar trend was observed with respect to nutrient uptake (NPK) by wheat straw as a result of differential times of planting. Thus, the early sown wheat crop provided the crop favorable conditions with minimum competition imposed by reduced weed population and dry matter accumulation for better growth viz. number of tillers, dry matter accumulation, leading to better

Table 2: Effect of varieties and sowing environments on N, P and K uptake by grain and straw of wheat at harvest

Treatments	Grain uptake (kg/ha)			Straw uptake (kg/ha)		
	Nitrogen	Phosphorous	Potassium	Nitrogen	Phosphorous	Potassium
Factor (A) Varieties						
PBW-175	34.05	8.29	9.69	12.65	4.32	24.53
JAUW-598	41.79	10.06	12.06	15.00	5.16	29.11
SEm±	0.75	0.18	0.21	0.23	0.08	0.44
CD (5%)	2.19	0.53	0.62	0.67	0.23	1.33
Factor (B) Sowing Environment						
31st October	52.86	13.21	15.44	19.63	6.46	37.27
15th November	48.54	11.84	13.46	17.23	5.87	34.16
30th November	43.06	9.99	11.88	16.03	5.43	30.76
15th December	34.80	8.27	9.98	13.33	4.67	25.68
30th December	26.51	6.53	7.87	9.49	3.37	18.68
14th January	21.75	5.21	6.61	7.24	2.65	14.36
SEm±	1.29	0.31	0.37	0.39	0.14	0.77
CD (5%)	3.79	0.91	1.08	1.15	0.40	2.25
Interaction (A*B)	NS	NS	NS	NS	NS	NS

yield attributes of wheat thus resulted in higher yields and nutrient uptake in wheat. Also, the delay in sowing might have resulted the seeds to face a drier soil environment in the later growing periods and hence affected the growth and biomass production, led to low nitrogen uptake. These results are in close conformity with the findings of Khalifa *et al*. (1977), Mahajan *et al*. (2018) and Gill *et al*. (2009).

CONCLUSION

In general, the pH of the soil decreased and EC increased after harvest of wheat crop. However, the organic carbon of the soils decreased after completion and harvest of wheat crop. However, among wheat varieties, numerically lower values of available N, P and K were recorded with wheat variety *PBW-175* as compared to wheat variety *JAUW-598*. With reference to sowing environments, numerically lowest values of available N, P and K were recorded in 31st October planting and was followed by 15th November sown wheat crop whereas the highest values of available N, P and K were recorded in 14th January planting and was followed by 30th December sown wheat crop. As regards the nutrient (NPK) uptake, wheat varieties significantly differed with each other. Wheat variety *JAUW-598* recorded significantly higher values of (NPK) uptake by grain and straw as compared to wheat variety *PBW-175*. With regards to sowing environments 31st October planting removed significantly highest amounts of nutrient (NPK) uptake by wheat grain and straw and was followed by each 15 days of delay in sowing dates.

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